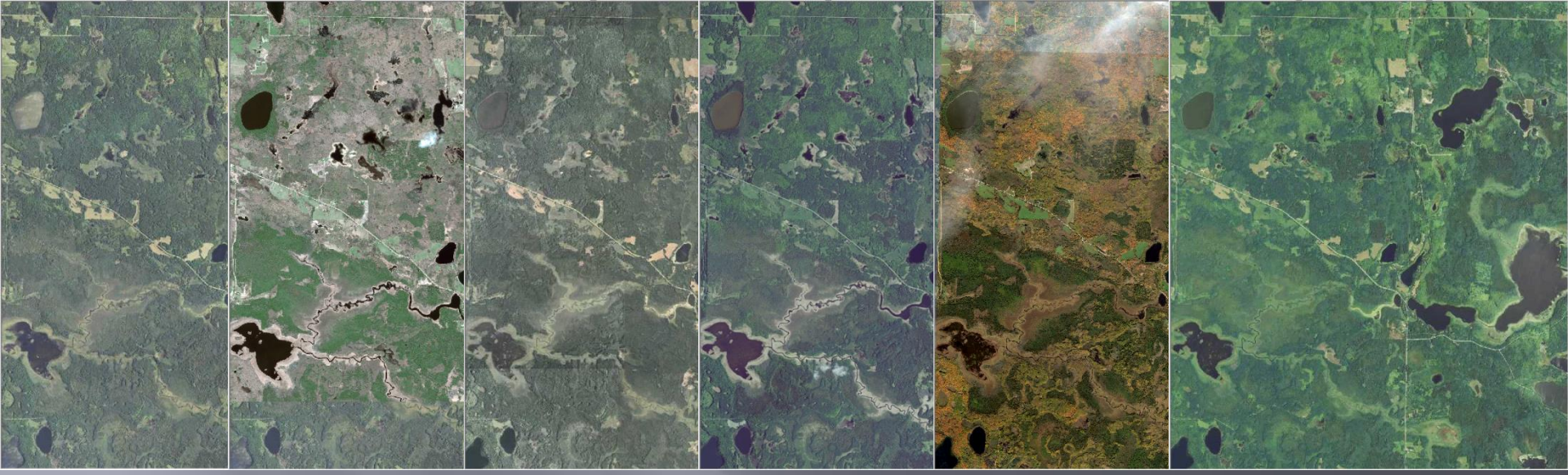


CHARACTERIZING FOREST DISTURBANCE AT THE WATERSHED SCALE:

ON CREATING A RISK-BASED APPROACH FOR ASSESSING BMP EFFECTIVENESS

MFRC Council Meeting
January 2015

Jennifer Corcoran, MN DNR
Rob Slesak, MFRC
Dick Rossman, MN DNR

Minnesota Department of Natural Resources

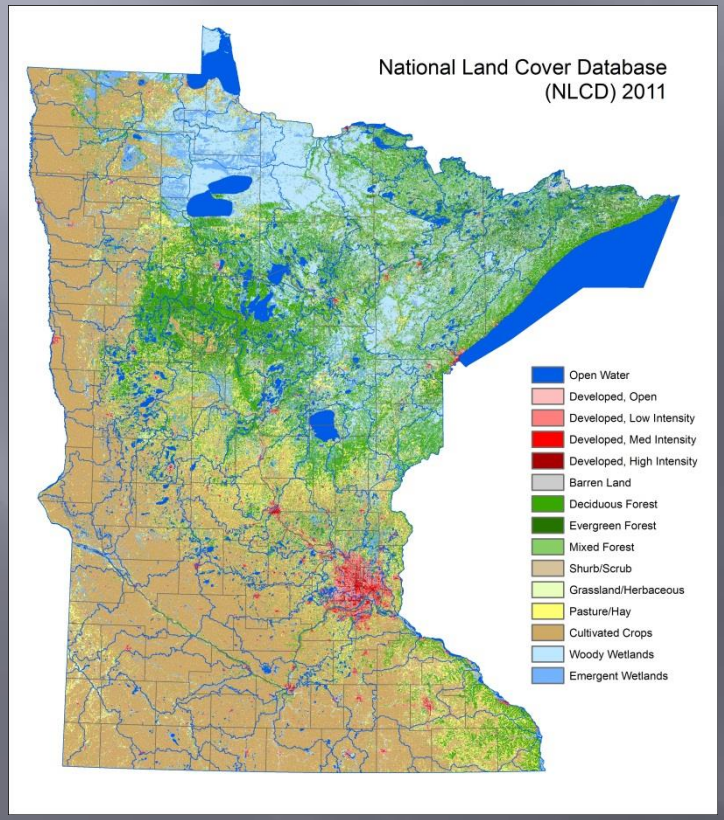
Minnesota Forest Resources Council

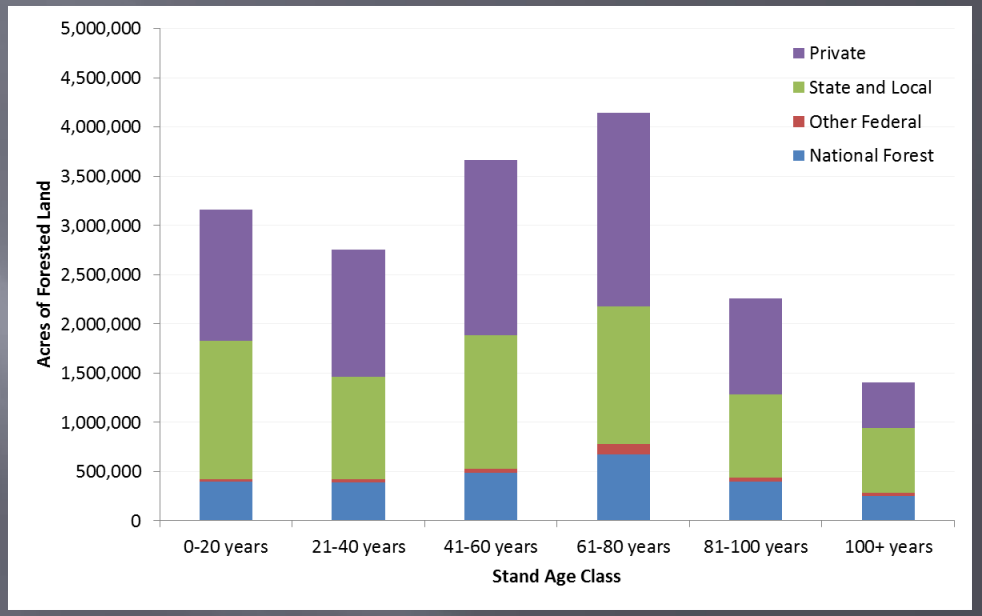
MN Forestry at a Glance

~17 mil. ac. of forestland

~30% of the state

(estimate includes: deciduous, evergreen, and mixed forest, and woody wetlands)





- 60-70% winter harvest
- Predominantly clearcut with residuals
- >8 million acres certified
- Comprehensive, voluntary BMPs

BMPs are Generally Effective

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
AUGUST AMERICAN WATER RESOURCES ASSOCIATION 2005

WATER RESOURCES BULLETIN
VOL. 5 AMERICAN WATER RESOURCES ASSOCIATION OCTOBER 1993

FOREST PRACTICES AS NONPOINT SOURCES OF POLLUTION IN NORTH AMERICA[1]

Dan Binkley and Thomas C. Brown[2]

T: Forest management activities may substantially alter
of water draining forests, and are regulated as nonpoint
pollution. Important impacts have been documented, in
s, for undesirable changes in stream temperature and
ions of dissolved oxygen, nitrate-N, and suspended sedi-
present a comprehensive summary of North American
t have examined the impacts of forest practices on each
arameters of water quality. In most cases, retention of
ffer strips along streams prevents unacceptable increas-
am temperatures. Current practices do not typically
dition of large quantities of fine organic material to
nd depletion of streamwater oxygen is not a problem;

regulations (Brown *et al.*, 1993). In some cases, forest practices have resulted in large or unacceptable changes in stream temperature and concentrations of dissolved oxygen, nitrate-N, and suspended sediments. In this paper, we review the impacts of forest practices on these four parameters of water quality. This is a synopsis of a detailed cataloging of the effects of forest management on water quality based on experiments in more than 40 experimental forest areas in the United States and Canada (Binkley and

RIPARIAN MICROCLIMATE AND STREAM TEMPERATURE RESPONSE TO FOREST HARVESTING: A REVIEW[1]

R. Dan Moore, D. L. Spittlehouse, and Anthony Story[2]

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
OCTOBER AMERICAN WATER RESOURCES ASSOCIATION 2006

EFFECTIVENESS OF TIMBER HARVEST PRACTICES FOR CONTROLLING SEDIMENT RELATED WATER QUALITY IMPACTS[1]

Edward B. Rashin, Casey J. Clishe, Andrew T. Loch, and Johanna M. Bell[2]

ABSTRACT: Timber harvest best management practices (BMPs) in Washington State were evaluated to determine their effectiveness at achieving water quality standards pertaining to sediment related effects. A weight-of-evidence approach was used to determine BMP effectiveness based on assessment of erosion with sediment delivery to streams, physical disturbance of stream channels, and aquatic habitat conditions during the first two years following harvest. Stream buffers were effective at

Rashin, Edward B., Casey J. Clishe, Andrew T. Loch, and Johanna M. Bell, 2006. Effectiveness of Timber Harvest Practices for Controlling Sediment Related Water Quality Impacts. Journal of the American Water Resources Association (JAWRA) 42(5):1307-1327.

Sediment delivery in managed forests: a review

J.C. Croke and P.B. Hairsine

Abstract: The opening or removal of forest canopies during harvesting or land clearing results in a predictable sequence of responses, the descriptions of which appear remarkably similar around the world. Such activities are now widely acknowledged to have adverse impacts upon water quality and in-stream ecology. Sediment delivery, therefore, encapsulates the dominant process by which water resources are impacted and the process that can be best managed to limit off-site impacts. This paper is a review of current processes, and perceptions, of sediment delivery in managed forests. We outline the major components

Effective <u>when implemented properly</u>

Monitoring Program History

SFRA mandates guideline monitoring

- DNR: programmatic aspects
- MFRC: oversight and direction

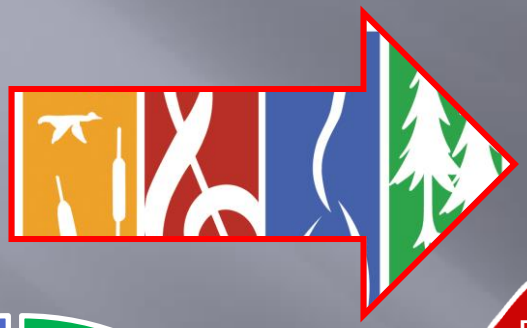
Monitoring is essential to the voluntary approach for guideline application

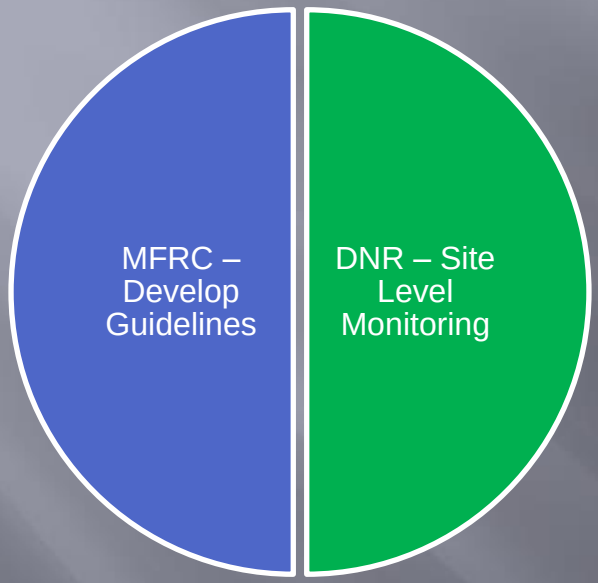
- Stakeholder demand
- Periodic reports used to guide training
- Linkages with certification programs

Historic method was biennial, statewide
NEW method is focused on watershed scale

- Same general protocol
  - Image analysis -> site selection -> field monitoring
- 3rd party contractors
- Monitoring all guidelines

Guideline Monitoring Program





Analysis Recommendations
Strategies to Improve BMPs
Research & Development

DNR – Watershed Scale Analyses
- Data Integration
- Data Interpretation
- Applications and Collaboration

MFRC – Develop Guidelines
- Selecting Indicators
- Operational Considerations
- Oversight of Program

DNR – Site Level Monitoring
- Data Collection
- Implications for Planning
- Reporting

Field Data Collection &
Methods Development
Outreach & Communication

Guideline Development
Upholding the SFRA
Training Coordination

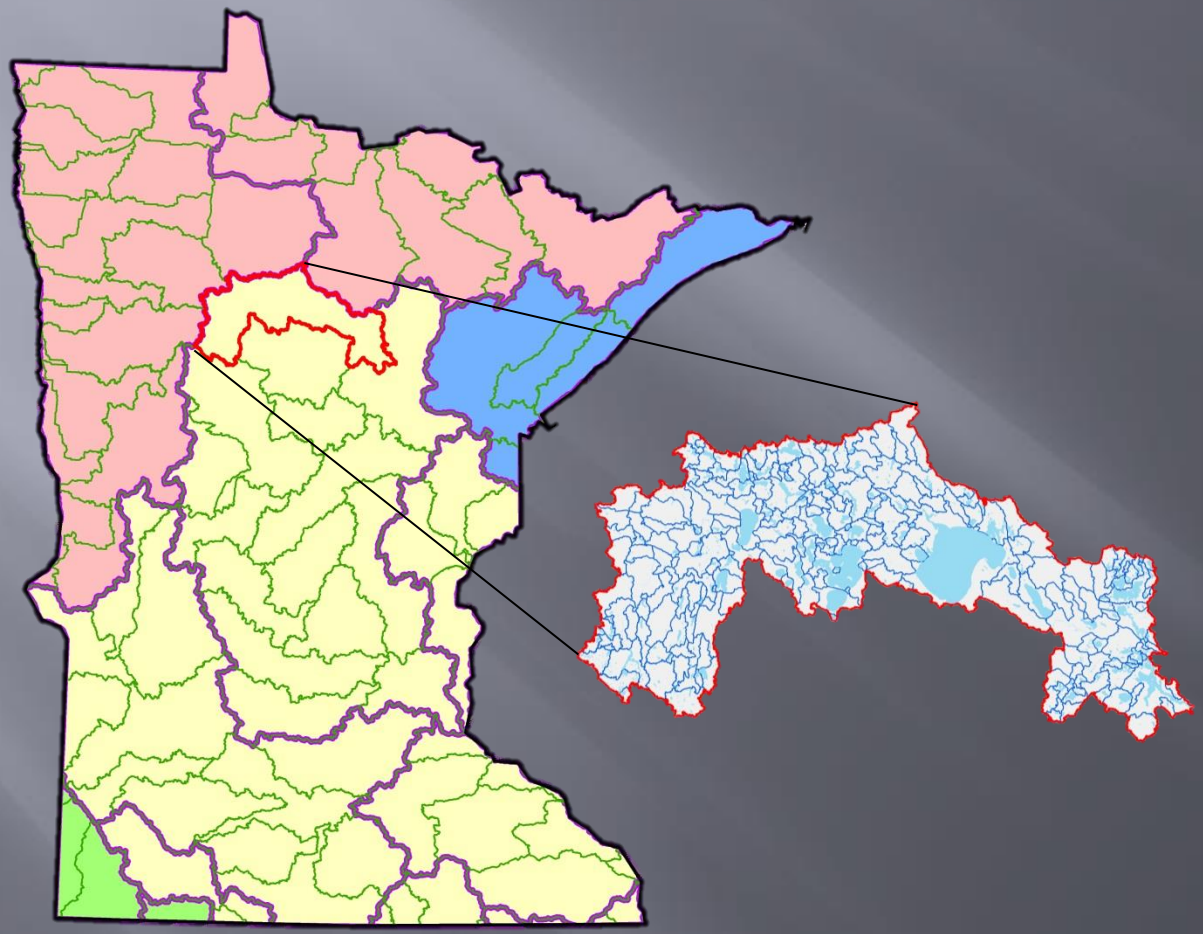
Implementation & Effectiveness

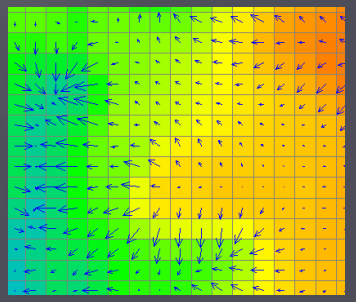
- Implemented at all?
- Implemented properly?
- Implemented properly and effective?

Range of conditions:

- Equipment/Operators
- Topography/Soils
- Season of harvest
- Weather/Climate
- Region/Watershed

What is a Watershed?





Scale of Analyses

Monitoring has historically been conducted statewide

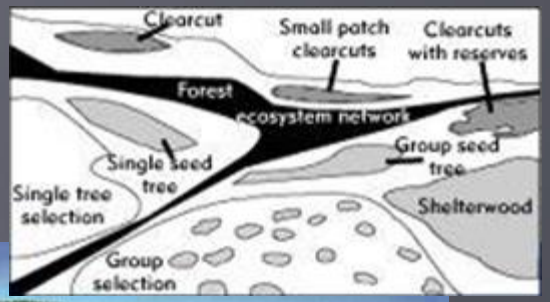
Watershed scale most relevant for water quality related research/analyses

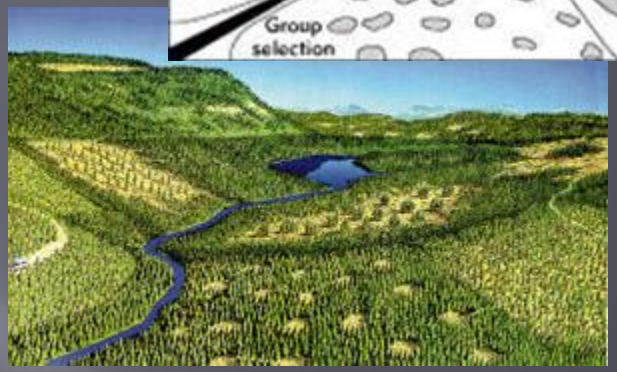
More/most agencies are following a watershed scale approach for management

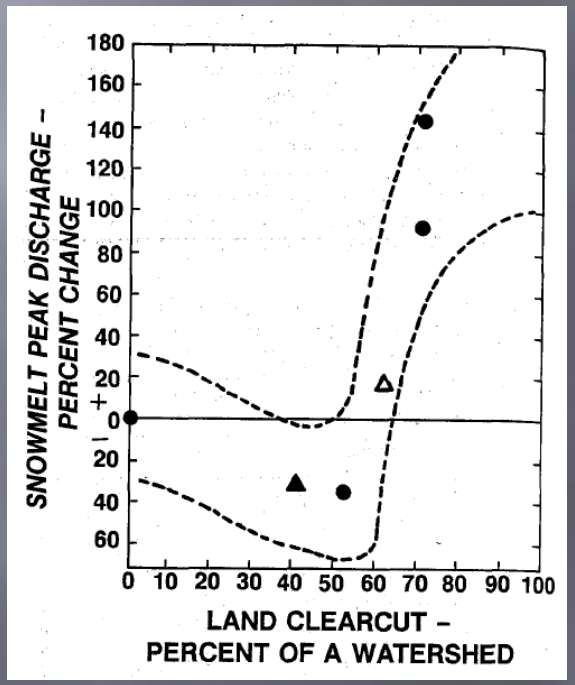
Disturbance Patterns

Forest disturbance can alter watershed hydrology

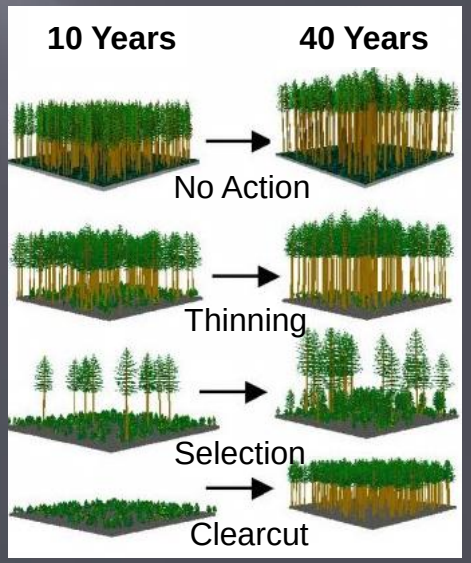
- Alter timing, magnitude of peakflow
- In-stream sediment production
- Nutrient loading in water bodies







Verry, 1986



Approach Overview

1. Quantify forest disturbance at watershed and state scales
   - Location, type of disturbance (classified only at watershed scale)

     Example classification scheme:

     'Natural' = fire, blowdown, disease, pest, flooding

     'Not Natural' (relating to a land use practice) = clearcut, thinning, partial cut, shelterwood, gap clearcuts, land use/cover conversion

2. Conduct field monitoring at selected sites
   - *New* - sites are selected within HUC 8 scale watersheds
   - Monitor for implementation and effectiveness of BMPs

Approach Overview

3. Ancillary data collection to 'characterize' the watershed
   - Example data layers to evaluate (in no particular order):
     - Area, density, and classification of 'disturbed' forest
     - Length of streams/roads crossing within disturbed areas
     - Area/length, density of water features (+ wetlands and trout streams/lakes)
     - USGS stream gauge (peak flow, low flow, average per season)
     - MPCA impaired waters (nutrient loading vs sediment)
     - Distance from disturbed areas to nearest water feature (wetland vs other)
     - Land cover composition and change (NLCD 2001, 2006, 2011)
     - Ecological classification, land type association, native plant community
     - FIA: forest age class, species, ownership type
     - Area/length, density of roads (state forest vs DOT)
     - Climate/weather (precipitation, temperature)
     - Soils (type, drainage class, available water storage, soil organic carbon)
     - Elevation/slope, flow model, wetness indices, soil erosion susceptibility

Approach Overview

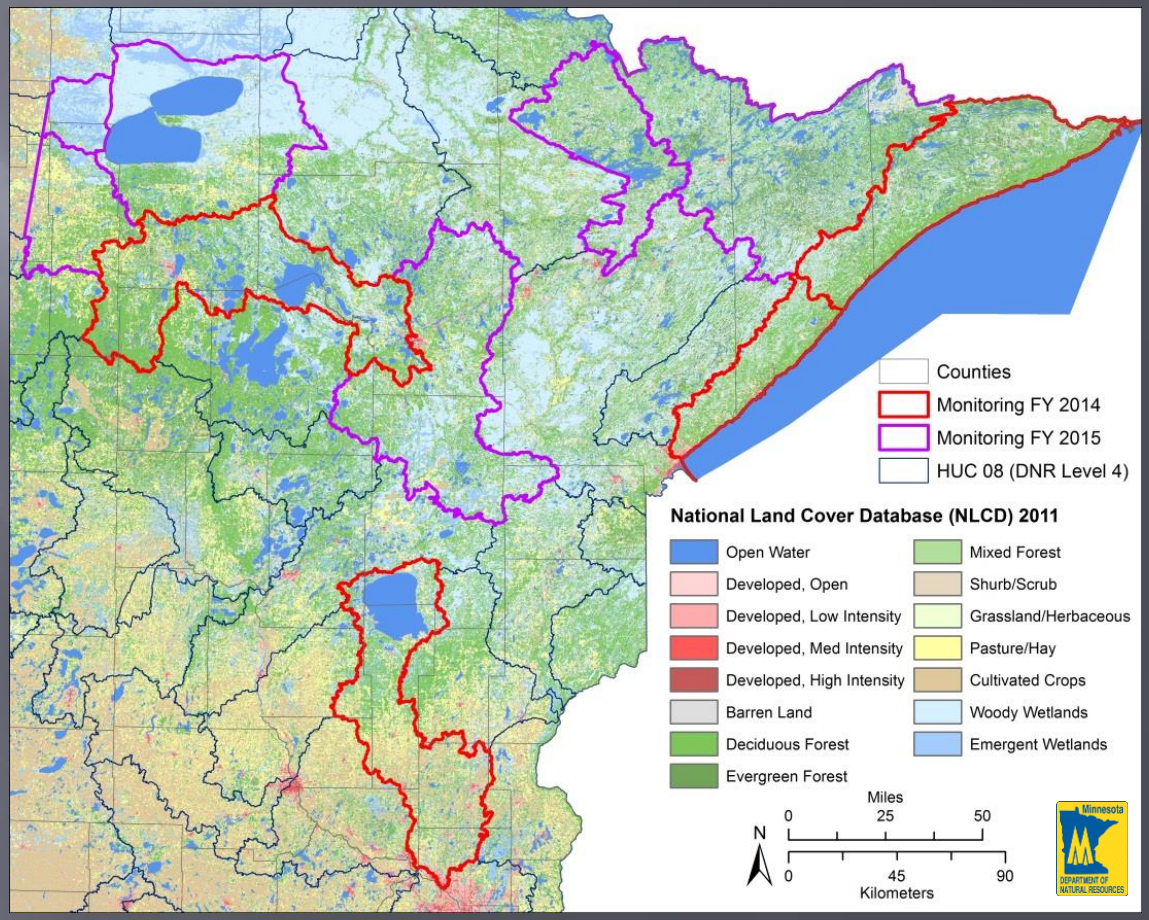
4. Combine info from 1, 2, and 3 to develop a *relative assessment* of risk to water quality by watershed
   - Risk metrics, weighting, conceptual frameworks, modeling

5. Target education and outreach based on info from 4

Site Scale - Field Monitoring

New

- Four watersheds annually on a recurring cycle
  - Following the MPCA WRAPS program
- 30-40 harvest sites per watershed
  - Stratified random selection
    - Each ownership type represented



Site Scale - Field Data Collection

Not Changed

- Calibration training
- Site level evaluation, pre-site and on-site survey
- Spatially referenced database of findings

<u>Evaluate watershed trends in:</u>

- Overall implementation
- Effectiveness
- Risk factors for departure

Watershed Scale – Remote Sensing

DNR Resource Assessment

Map Disturbed Forestland

Regardless of disturbance type

Use Landsat Time Series

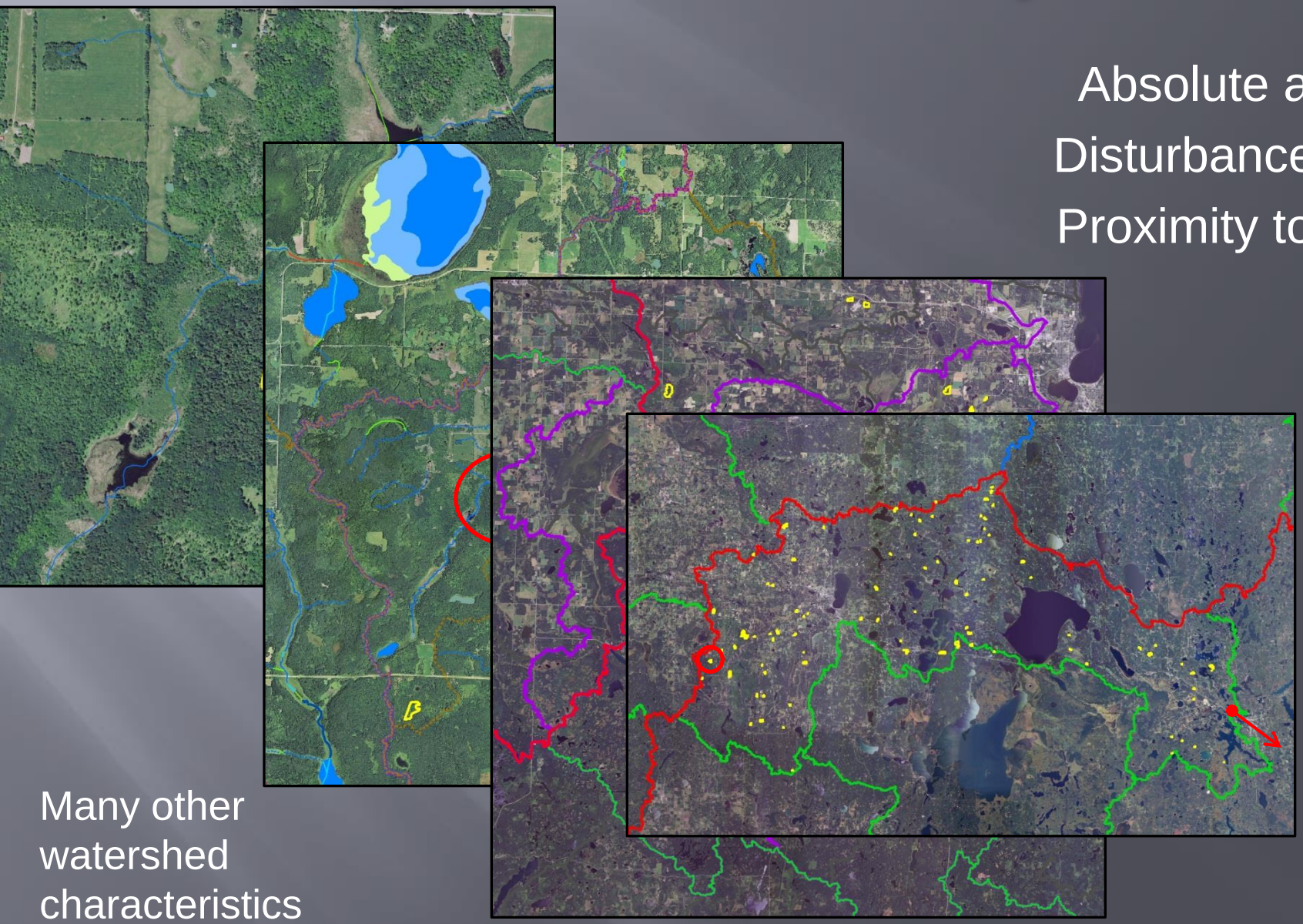
Or other aerial imagery

Verified with aerial photos flown

Annual: Selected Watersheds

Biennial: Statewide

Watershed Scale Analyses



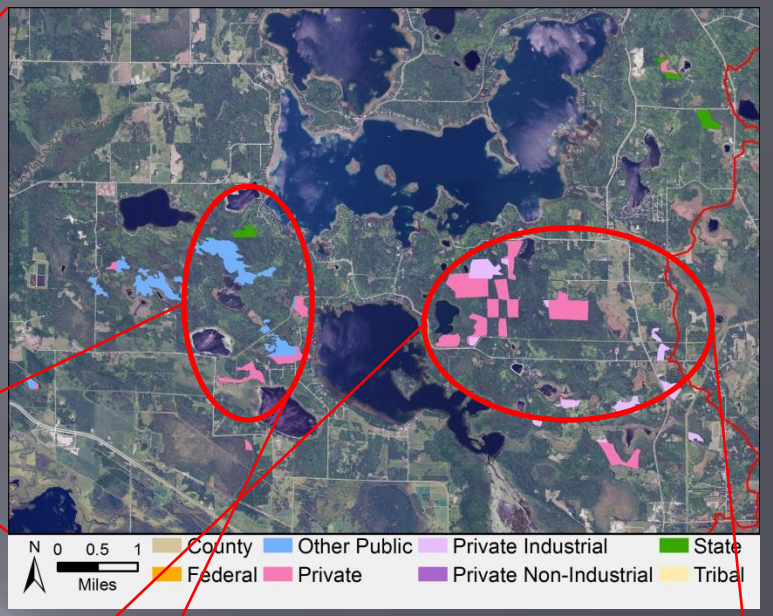
Absolute amount

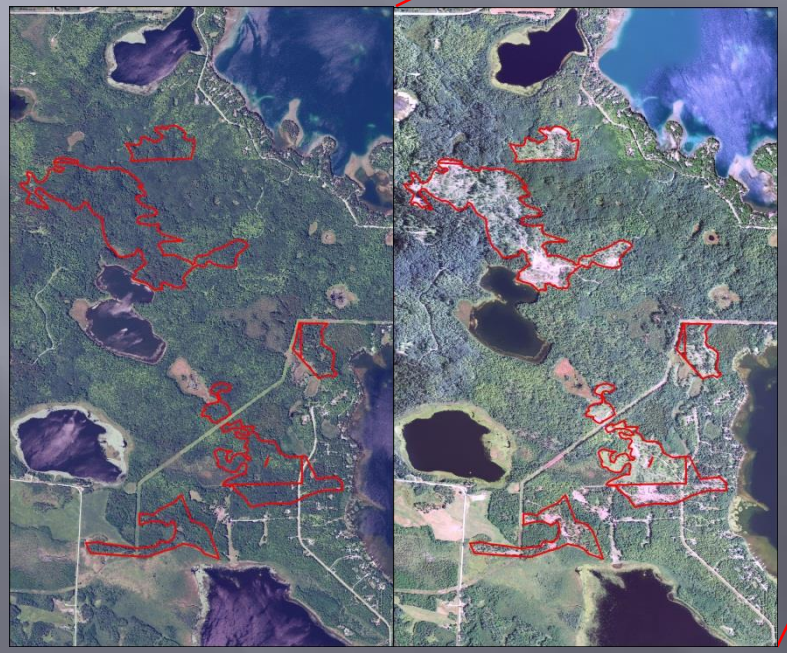
Disturbance types

Proximity to water

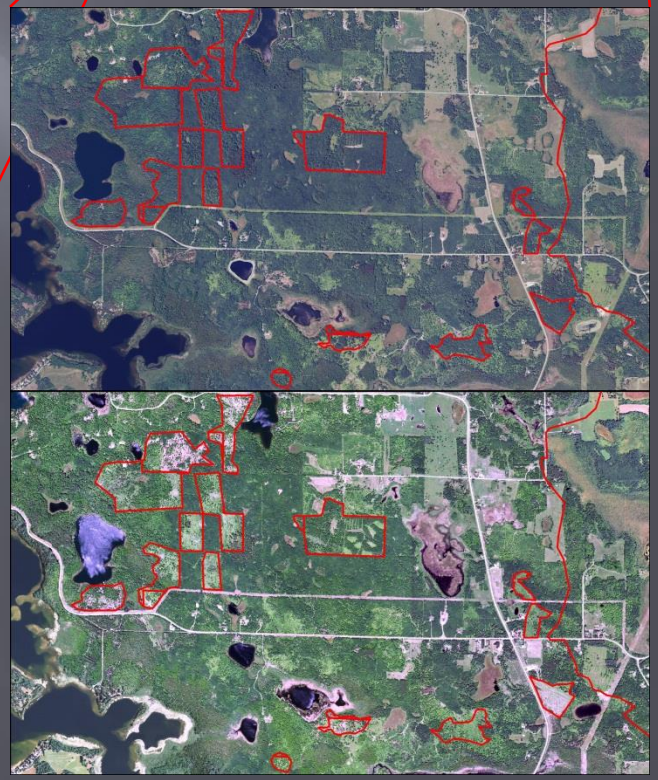
Many other watershed characteristics


July 28, 2014





2010 2013



2010

2013

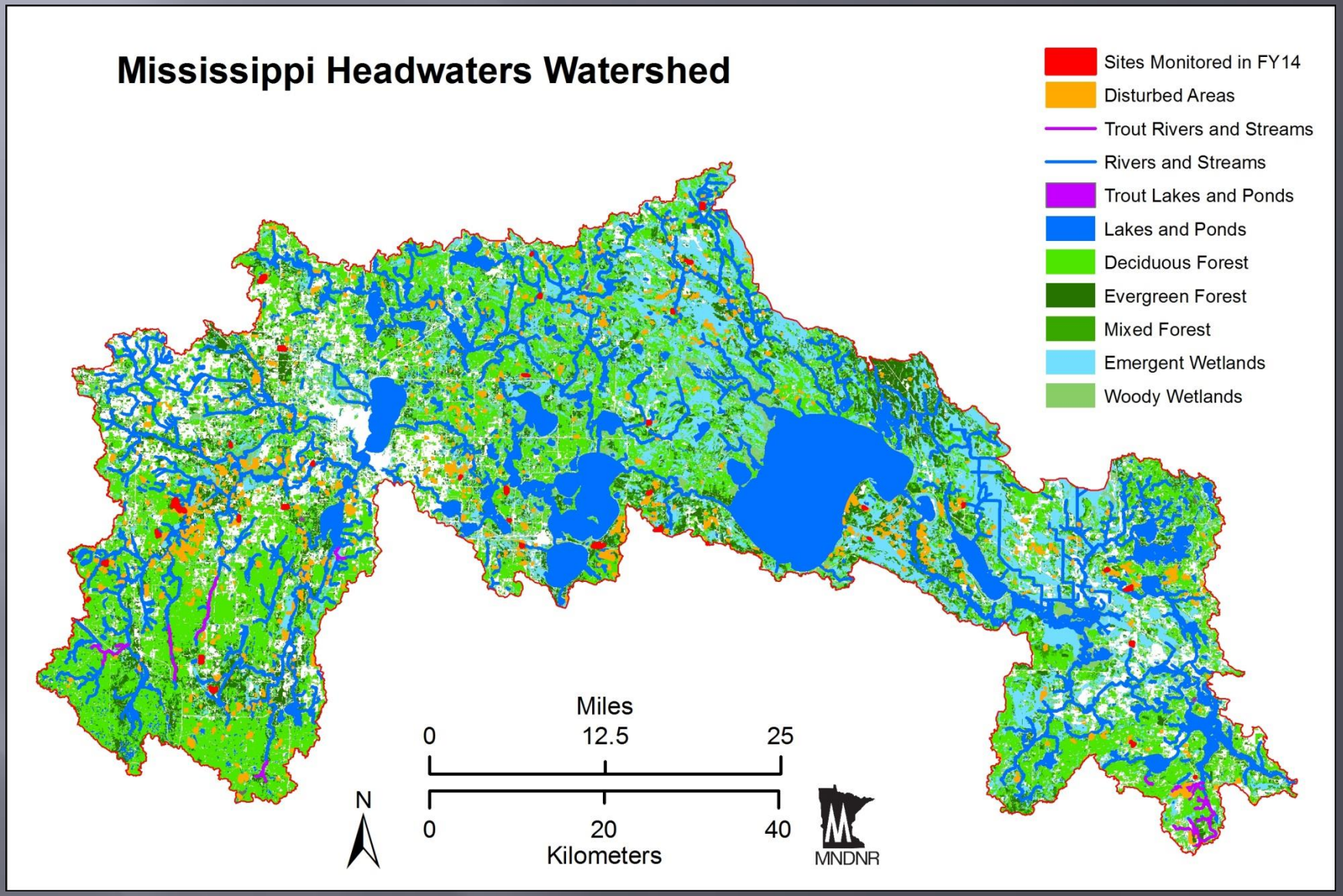
Preliminary Results – Characterizing Disturbance at a Watershed Scale

Lake Superior North and South, Mississippi Headwaters, and Rum River Watersheds:

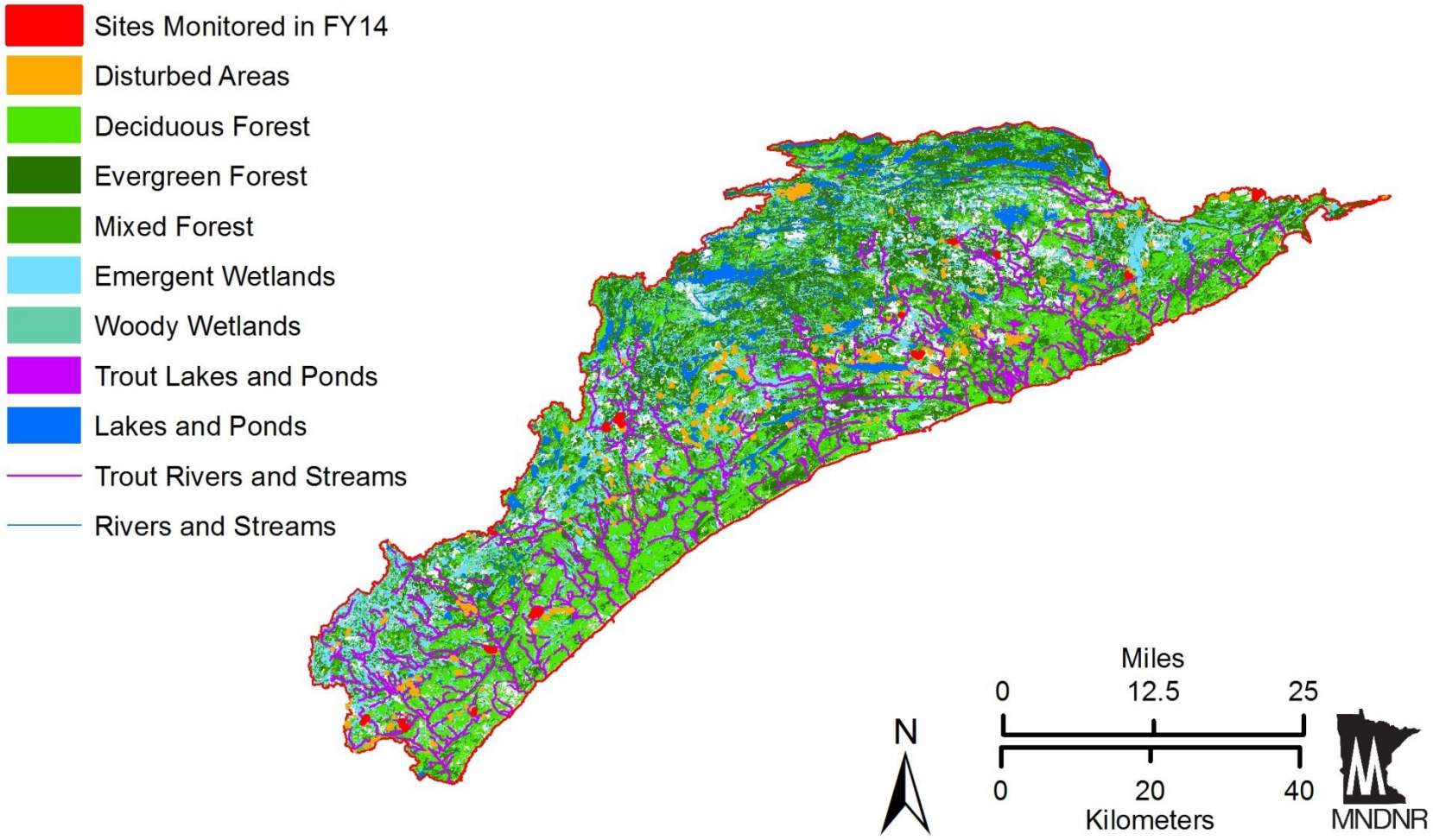
- Table summaries and maps
  - Forest and water features
- Disturbance types
- Distance to nearest water feature (DNR public waters, National Hydrography Datase)

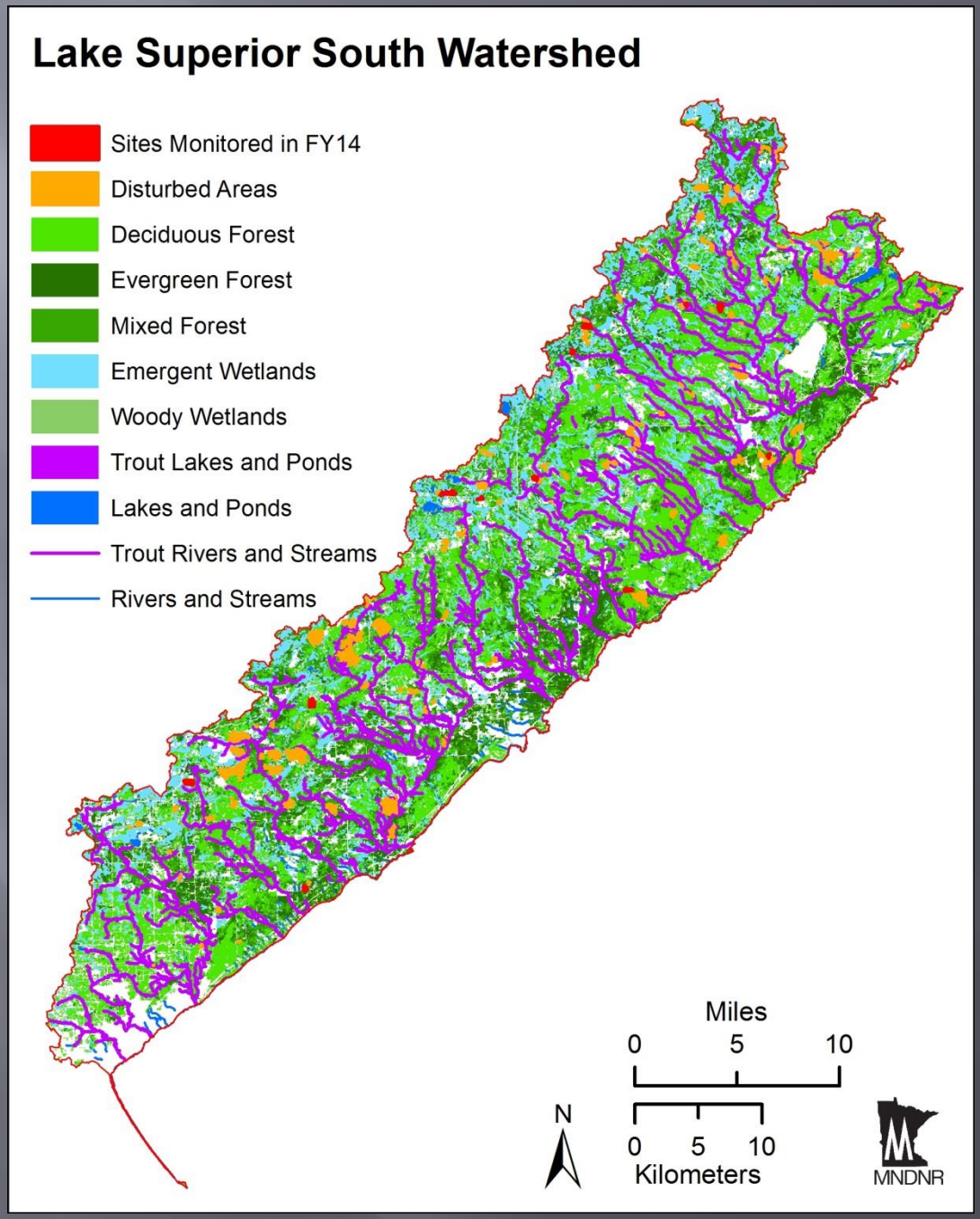
Preliminary Results – Characterizing Disturbance at a Watershed Scale

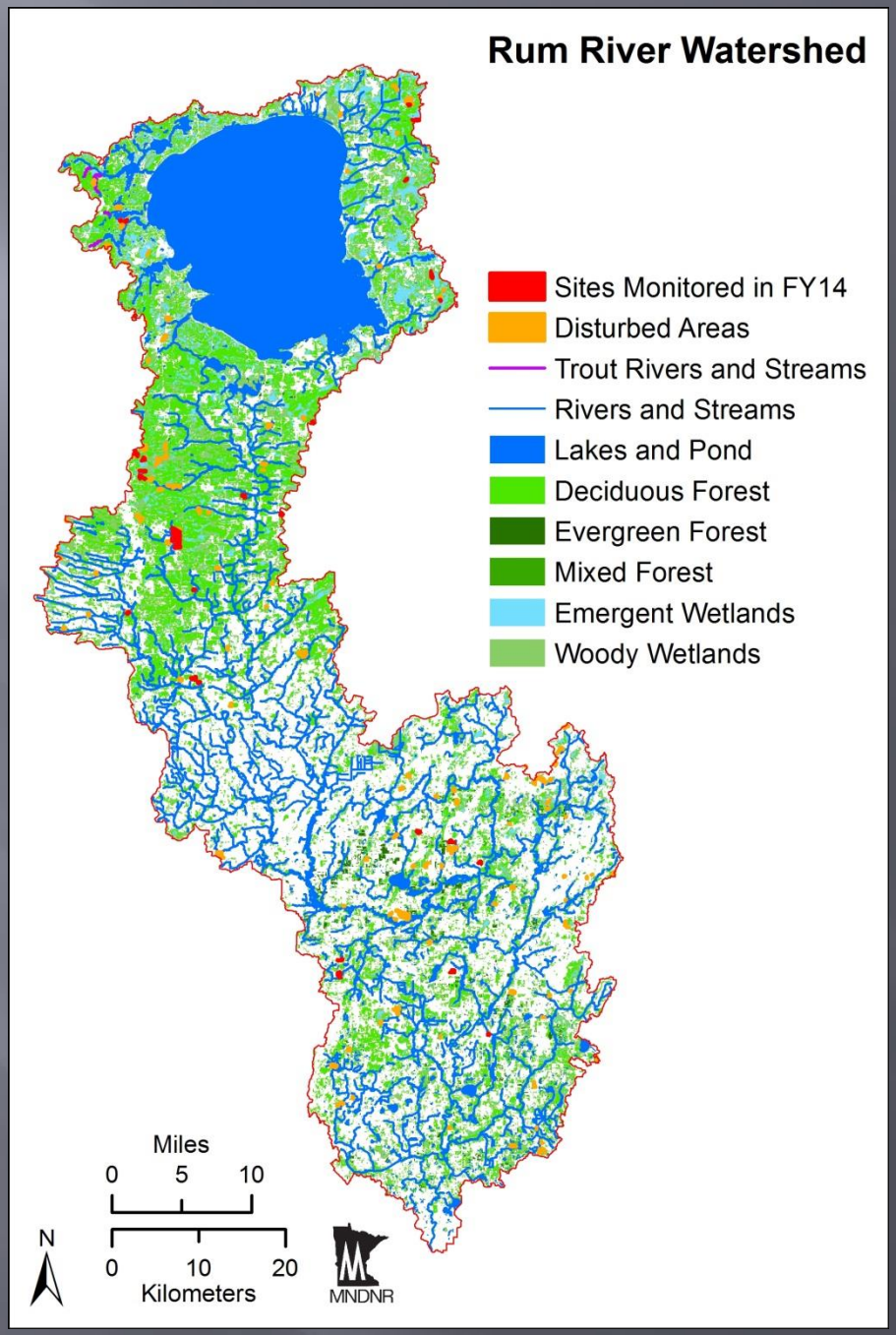
Key Attributes	Mississippi Headwaters	Lake Superior North	Lake Superior South	Rum River
Total Area of Watershed (acres)	1,228,890	1,015,660	399,264	1,013,290
Percent of Watershed in Forestland (%)	53	64	61	36
Percent of Watershed in Lakes and Ponds (%)	15	6	0	16
Percent Trout Lakes and Ponds (%)	0.2	4.3	3.2	0.0
Length of Rivers and Streams (miles)	1,575	2,144	1,055	1,801
Percent Trout Rivers and Streams (%)	3	53	75	0
Percent of Watershed in Wetlands (%)	23	20	23	17
Total Disturbed Area (acres)	23,825	10,021	7,984	3,962
Percent of Forestland Disturbed (%)	4	2	3	1
Area Monitored at the Site Level (acres)	1,173	923	320	975
Percent of Disturbed Area Monitored (%)	5	9	4	25
Number of Sites Monitored	36	17	13	28

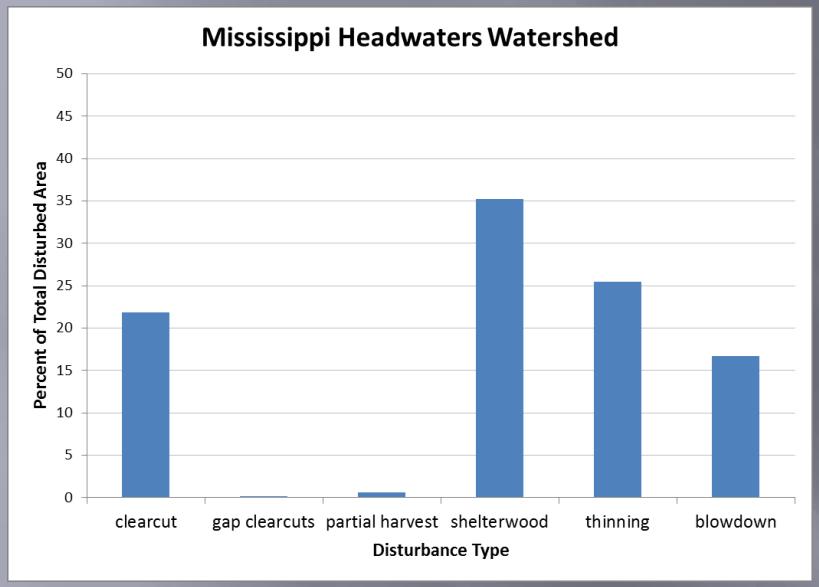

Mississippi Headwaters Watershed
Sites Monitored in FY14
Disturbed Areas
Trout Rivers and Streams
Rivers and Streams
Trout Lakes and Ponds
Lakes and Ponds
Deciduous Forest
Evergreen Forest
Mixed Forest
Emergent Wetlands
Woody Wetlands
Miles
0
12.5
25
N
0
20
40
Kilometers
MNDNR

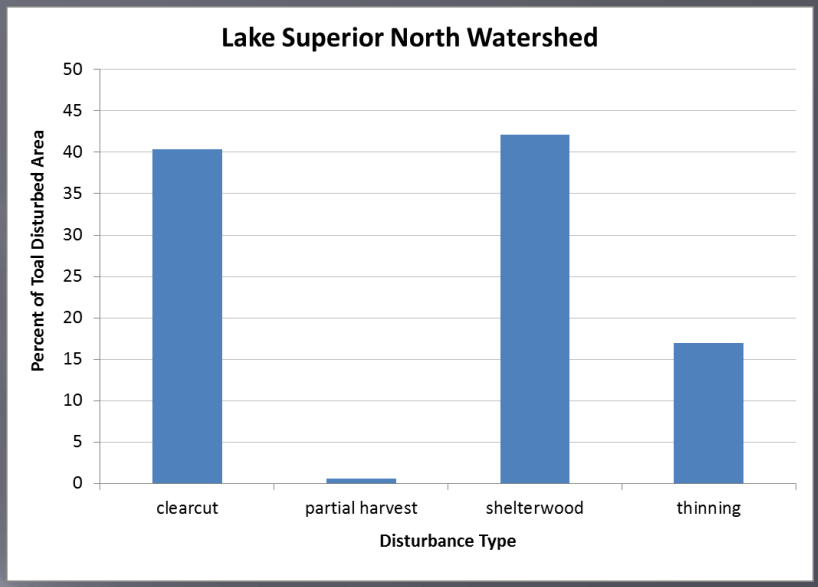
Lake Superior North Watershed

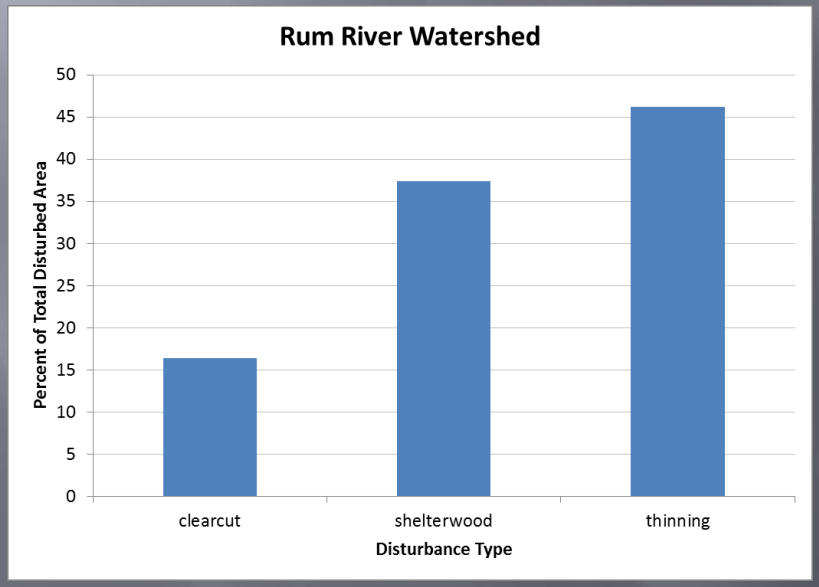


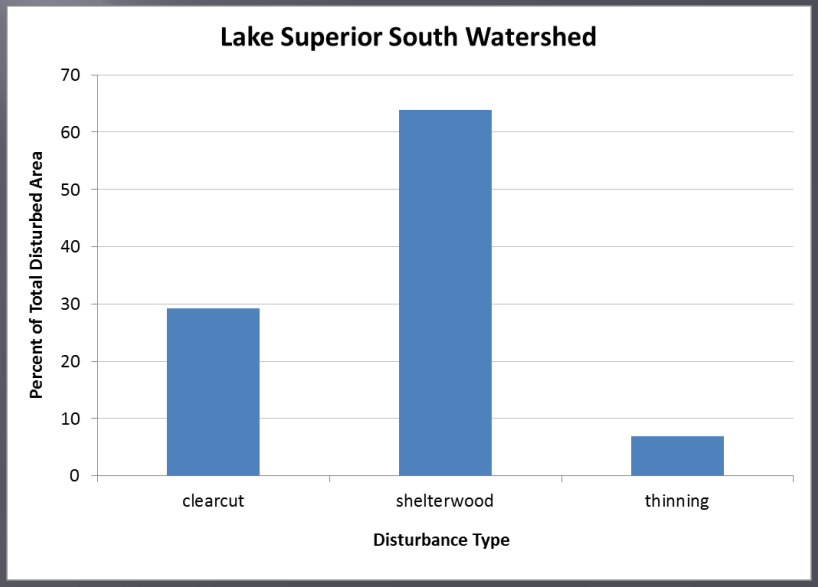

Lake Superior South Watershed
Sites Monitored in FY14
Disturbed Areas
Deciduous Forest
Evergreen Forest
Mixed Forest
Emergent Wetlands
Woody Wetlands
Trout Lakes and Ponds
Lakes and Ponds
Trout Rivers and Streams
Rivers and Streams
Miles
0 5 10
N
0 5 10
Kilometers
MNDNR

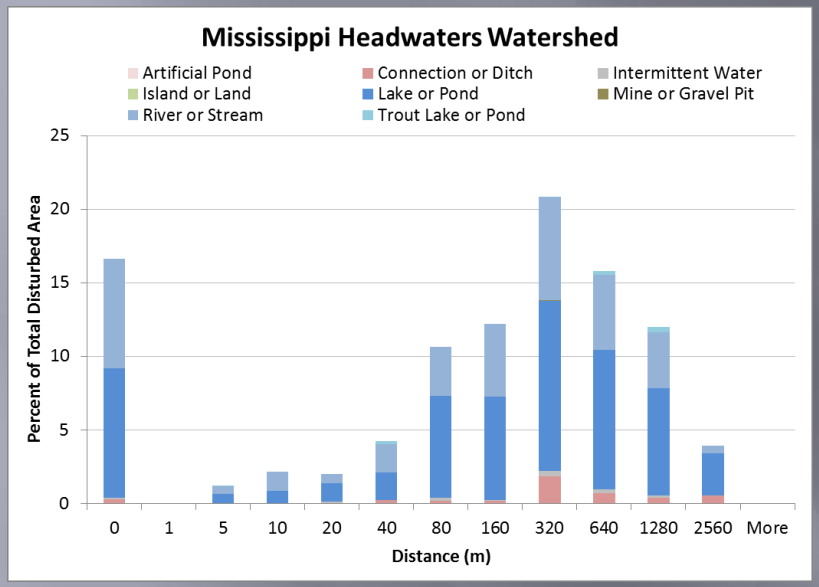

Rum River Watershed
Sites Monitored in FY14
Disturbed Areas
Trout Rivers and Streams
Rivers and Streams
Lakes and Pond
Deciduous Forest
Evergreen Forest
Mixed Forest
Emergent Wetlands
Woody Wetlands
Miles
0 5 10
N
0 10 20
Kilometers
MNDNR

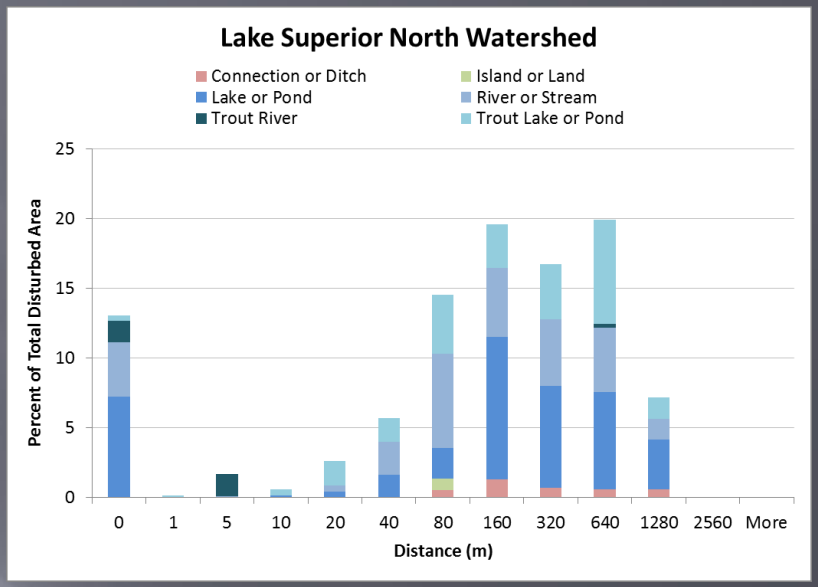

Mississippi Headwaters Watershed
Percent of Total Disturbed Area
50
45
40
35
30
25
20
15
10
5
0
clearcut
gap clearcuts
partial harvest
shelterwood
thinning
blowdown
Disturbance Type

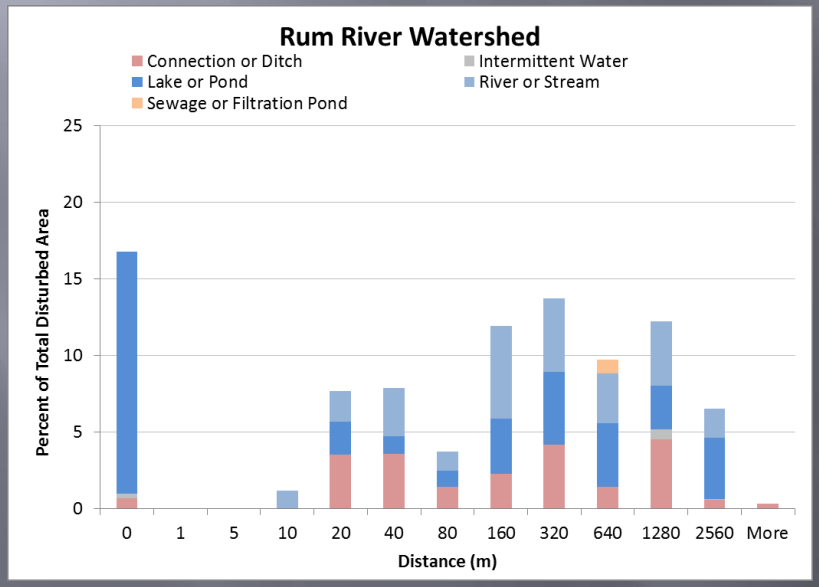

Lake Superior North Watershed
Percent of Toal Disturbed Area
50
45
40
35
30
25
20
15
10
5
0
clearcut
partial harvest
shelterwood
thinning
Disturbance Type

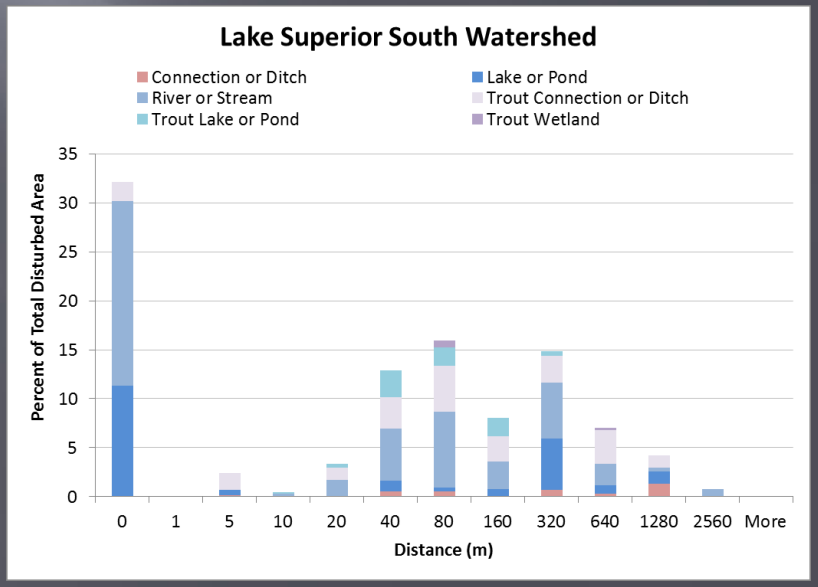

Rum River Watershed
Percent of Total Disturbed Area
50
45
40
35
30
25
20
15
10
5
0
clearcut
shelterwood
thinning
Disturbance Type

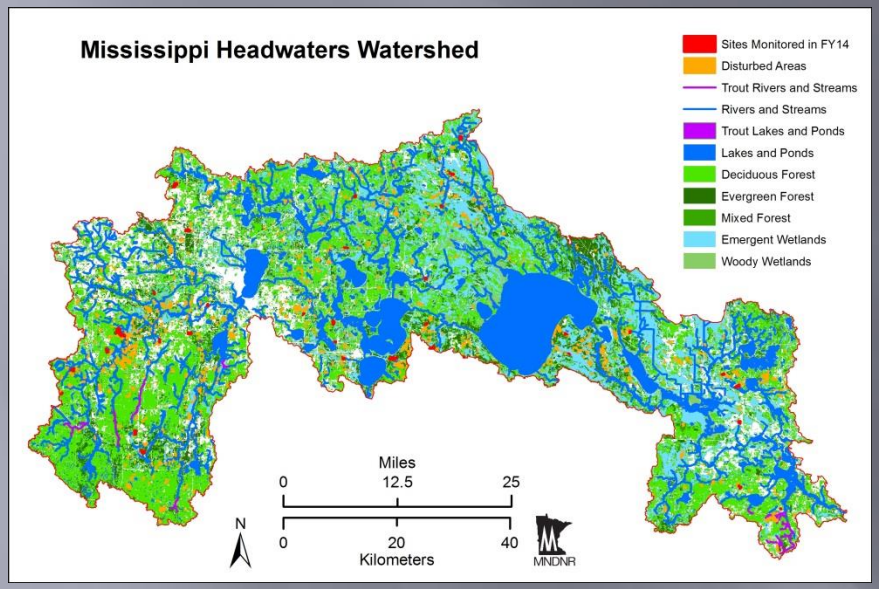

Lake Superior South Watershed
Percent of Total Disturbed Area
70
60
50
40
30
20
10
0
clearcut
shelterwood
thinning
Disturbance Type


Mississippi Headwaters Watershed
Artificial Pond
Connection or Ditch
Intermittent Water
Island or Land
Lake or Pond
Mine or Gravel Pit
River or Stream
Trout Lake or Pond
Percent of Total Disturbed Area
0
5
10
15
20
25
0
1
5
10
20
40
80
160
320
640
1280
2560
More
Distance (m)


Lake Superior North Watershed
Connection or Ditch
Island or Land
Lake or Pond
River or Stream
Trout River
Trout Lake or Pond
Percent of Total Disturbed Area
0
5
10
15
20
25
0
1
5
10
20
40
80
160
320
640
1280
2560
More
Distance (m)


Rum River Watershed
Connection or Ditch
Intermittent Water
Lake or Pond
River or Stream
Sewage or Filtration Pond
Percent of Total Disturbed Area
0
5
10
15
20
25
0
1
5
10
20
40
80
160
320
640
1280
2560
More
Distance (m)


Lake Superior South Watershed
Connection or Ditch
Lake or Pond
River or Stream
Trout Connection or Ditch
Trout Lake or Pond
Trout Wetland
Percent of Total Disturbed Area
0
5
10
15
20
25
30
35
0
1
5
10
20
40
80
160
320
640
1280
2560
More
Distance (m)


Mississippi Headwaters Watershed
Sites Monitored in FY14
Disturbed Areas
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Rivers and Streams
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Woody Wetlands
Miles
0 12.5 25
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Kilometers
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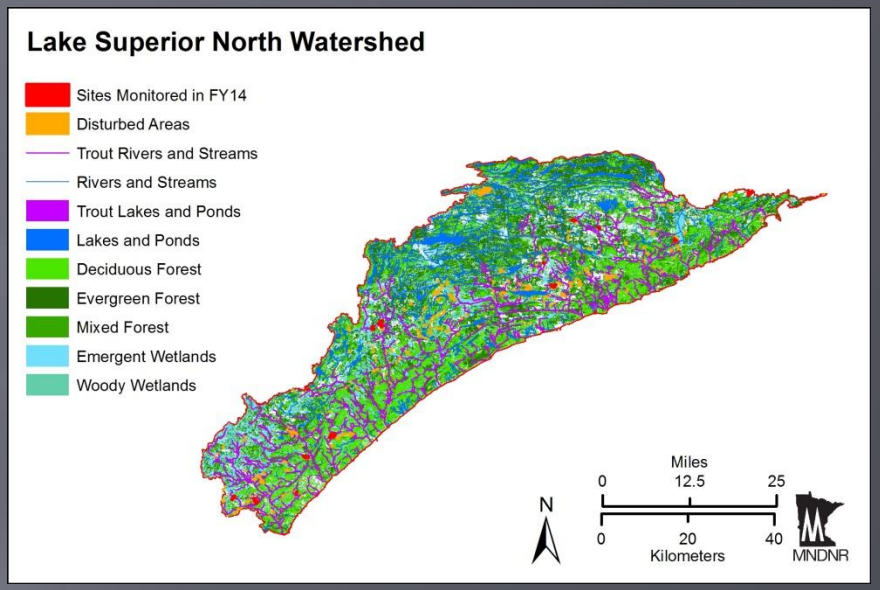
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Kilometers
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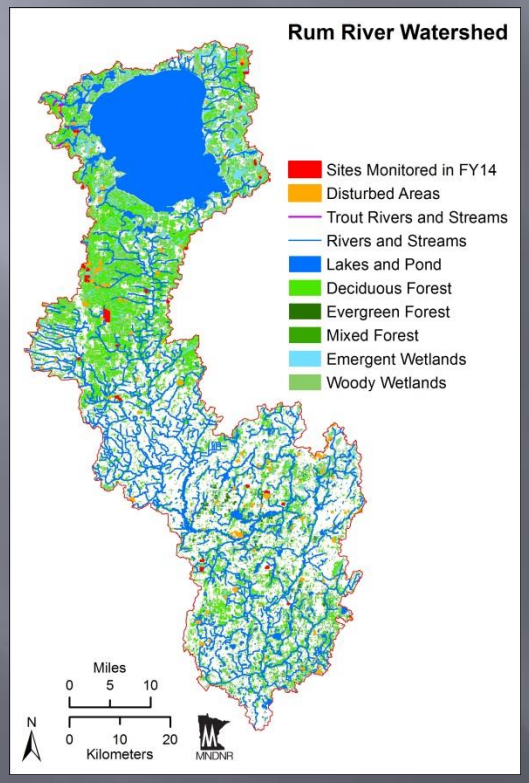
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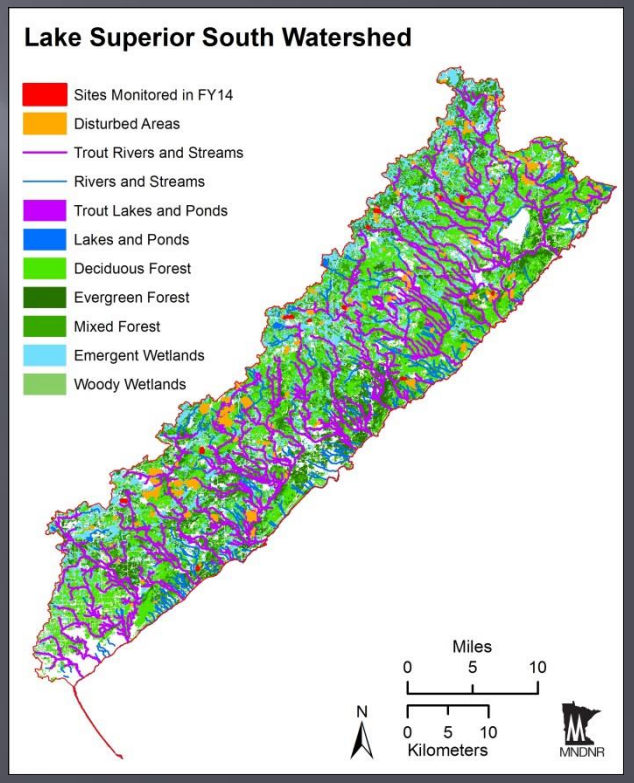
Woody Wetlands
Miles
0 5 10
N
0 10 20
Kilometers
MNDNR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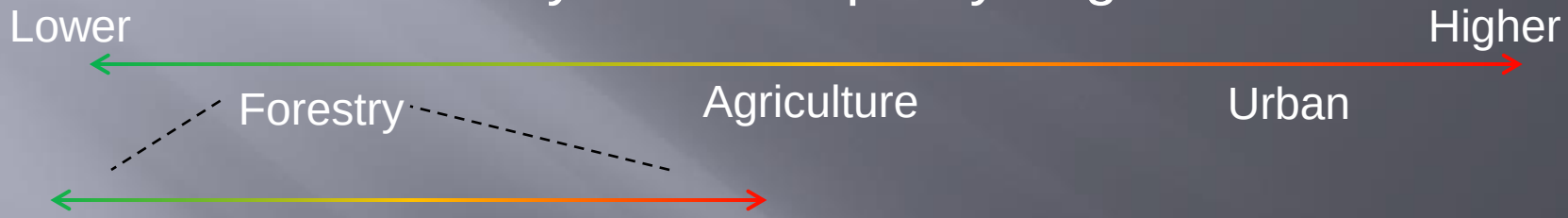
Emergent Wetlands
Woody Wetlands
Miles
0 5 10
N
0 5 10
Kilometers
MNDNR

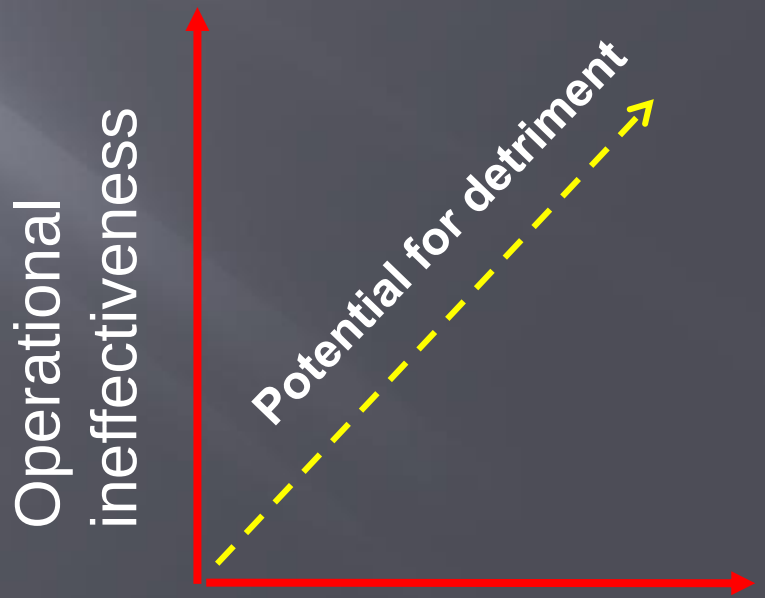
Assessing Relative Risk

Land Use Practices
Probability of water quality degradation



Extensive mngt.
Rapid re-vegetation
Level topography

Intensive mngt.
Adjacent to water
Erodible soils



Relative risk is a function of:
Operational effectiveness of practices
Disturbance patterns
Watershed characteristics

Assessing Risk at the Watershed Scale

Operational effectiveness scores

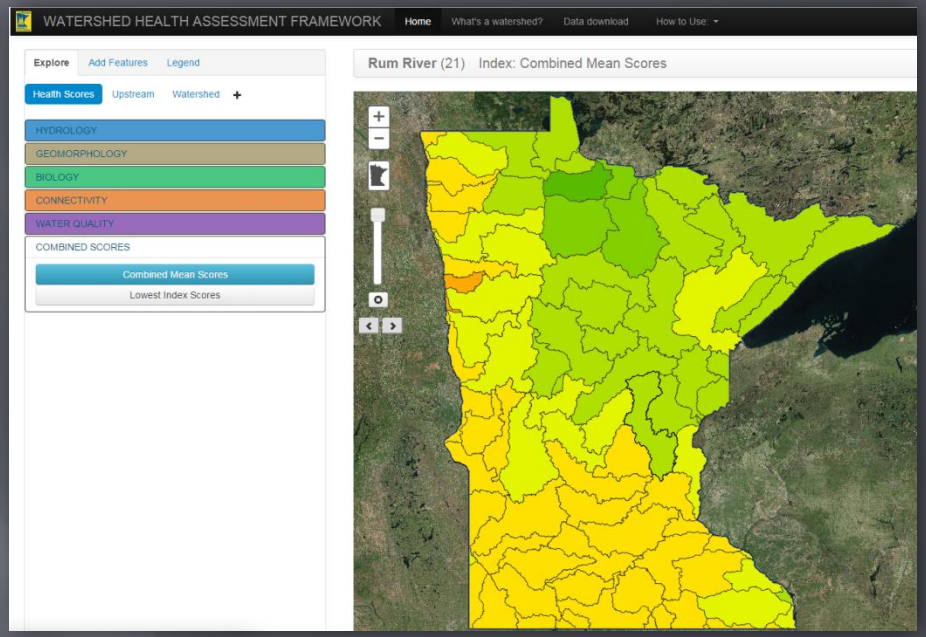
- Crossing density, erosion control, etc

Disturbance metrics

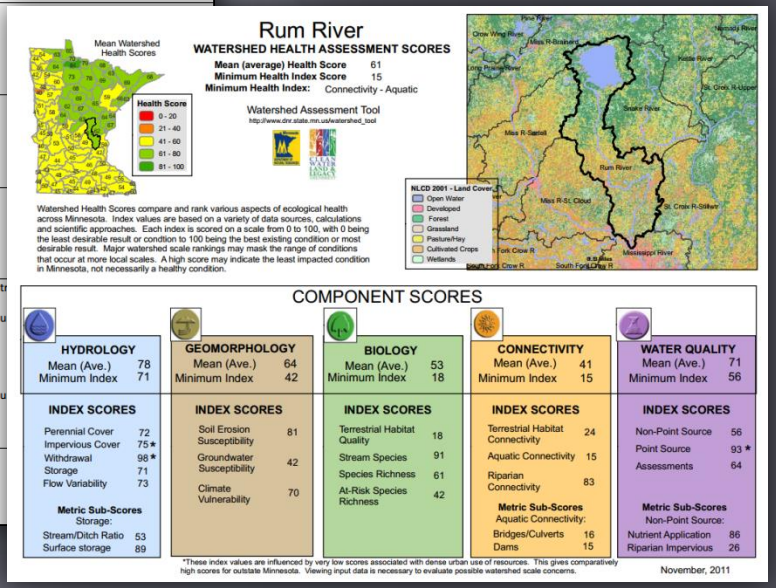
- Amount of recent disturbance
- Distribution in time and space
- Proximity to water

Watershed characteristics

- Landuse / landcover
- Road density and connectivity
- Many others



	Score:	80-100	60-80	40-60	20-40	0-20	
HYDROLOGY HEALTH INDEX:	**Description:**	**Least Impacted**		**Moderately Impacted**		**Heavily Impacted**	**DATA USED**
Perennial Cover	The amount of perennial cover remaining on the landscape compared to pre-settlement cover	80-100% perennial cover remains	60-80%	40-60% perennial cover remains	20-40%	0-20% perennial cover remains	• Marschner Circa 1890's Landcover; (MN DNR Forestry 1994) • National Land Cover Dataset (2001)
Flow Variability	Degree of deviation from expected flow patterns based on historic stream gage records and Indicators of Hydrologic Alteration	0-20% deviation from expected patterns	20-40% deviation	40-60% deviation from expected patterns	60-80%	80-100% deviation from expected patterns	•
Water Withdrawal	The total permitted water use (millions/gals/year) from all surface and groundwater sources plus estimate of water use from domestic wells	66-69000(mgy) permitted water use and domestic well use		200,000 - 265,000(mgy) permitted water use and domestic well use		536,600(mgy) permitted water use plus domestic well use estimate	•
Impervious Cover	% of catchments within a watershed that have greater than 4% impervious surface. (Score is the inverse of the percentage)	0-20% of catchments have 4% or greater impervious surface	20-40%	40-60% of catchments have 4% or greater impervious surface	60-80%	80-100% of catchments have 4% or greater impervious surface	•
Loss of Hydrologic Storage	Mean of two inputs: 1. Ratio of stream miles to ditch miles (in-channel storage) 0 = all ditch, 100 = all stream 2. % remaining surface water (includes hydric soils as historic wetland indicator) 0 = no surface features remain, 100 = all surface features remain	100-80 % hydrologic storage remains; almost no ditching and almost all surface water features still remain on the landscape	60-80%	40-60% of storage remains. Around half of the streams are ditched, and /or half of the surface water storage remains.	20-40	8-20% hydrologic storage remains. Most streams are ditched and very little surface water storage remains on the landscape	
HYDROLOGY MEAN SCORE:	Mean of 5 hydrologic health index values	100 -80	60-80	40-60	20-40	0-20	



Outcomes

Key Objective: Maintain supply of high-quality water from forests

ID factors influencing operational effectiveness

ID “highest” risk watersheds

Targeted outreach/planning

Engaged stakeholders and partners

Questions?

Acknowledgments

Forrest Boe

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